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Plastics

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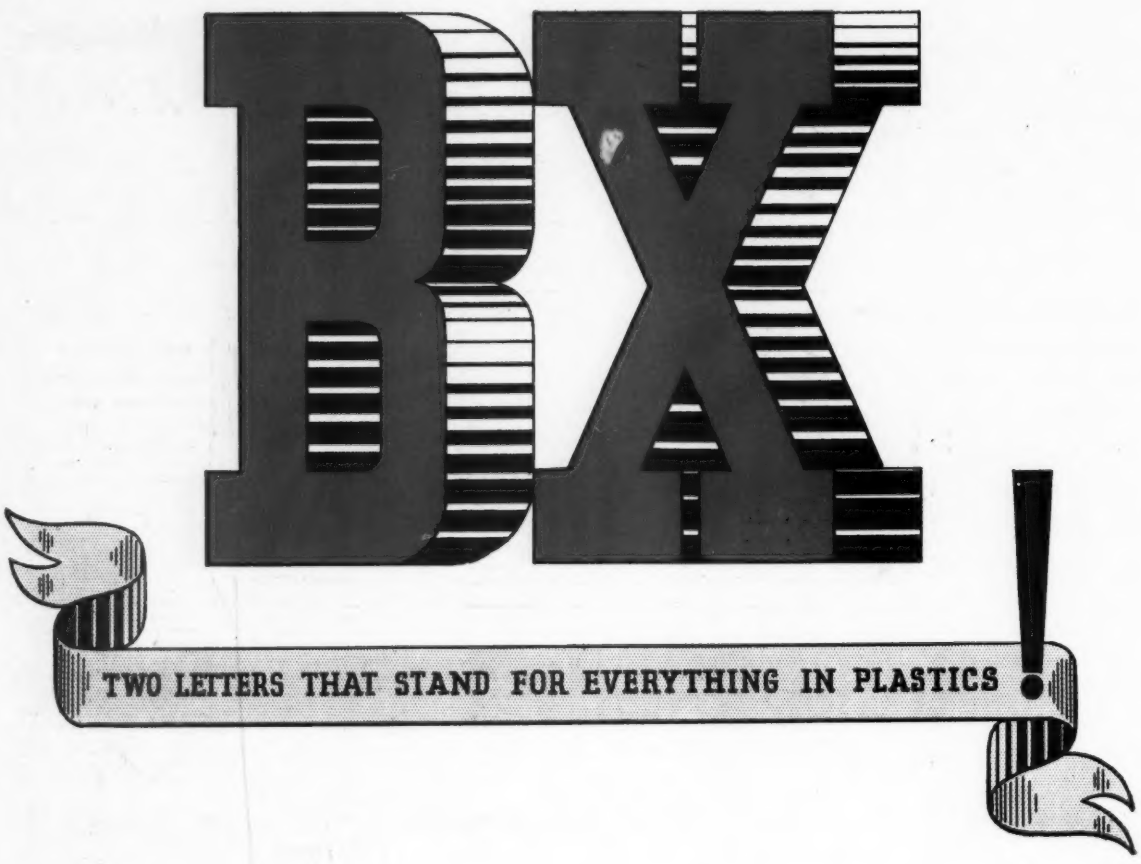

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Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Vol. IV OCTOBER, 1940 No. 41

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"PLASTICS" is published n London, England, at the beginning of each month.

Head Offices: Bowling Green Lane, London, E.C.1.

Inland Telegrams: "*Pressimus, Smith, London.*"
Cables - - "*Pressimus, London.*"
Telephone - *Terminus* 3636 *(Private Exchange).*

Midland Office — 50, Hertford Street, Coventry.
Telephone—Coventry 60095 *(2 lines).*
Telegrams—"*Presswork, Coventry.*"

Northern Offices—Manchester: Deansgate House, 274, Deansgate.
Telephone—Blackfriars 5038-9.
Telegrams—"*Presswork, Manchester.*"

SUBSCRIPTION—"PLASTICS" will be mailed regularly to any address in the United Kingdom or abroad for—
Twelve issues for 15s. post free; Canada and Newfoundland 12 for 13s. 6d.; pro rata for fewer numbers.

COMMUNICATIONS—All letters regarding subscriptions, advertisements and other business matters must be addressed to The Manager, Bowling Green Lane, London, E.C.1.

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Whilst to the experienced eye, two mouldings may look identical, there may actually be a world of difference in their reactions to service conditions. The reason of course, is in the original choice of moulding materials and their suitability, or otherwise, for the ultimate function of the moulding.

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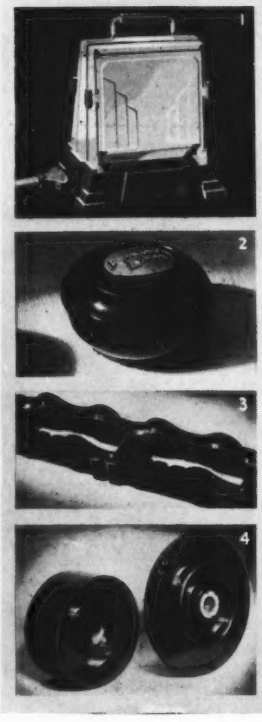

Bakelite Limited are always pleased to advise on the most suitable material to meet special requirements.

The illustrations show—(top) A section of the moulding materials store at our Birmingham works. (1) "Pyramid" Toaster; base moulded from heat-resisting material. (2) shaving bowl unaffected by soap and water. (3) Conveyor Chain, resistant to chemicals. (4) Moulded components for high-voltage switch-gear; the drum is 8" diameter by 4" face, and the disc is 11" diameter.

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T H E M A T E R I A L O F I N F I N I T E U S E S

Vol. IV. No. 41 OCTOBER, 1940

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.I.C.
Offices - Bowling Green Lane, London, E.C.1

PLASTICS IN AIRCRAFT CONSTRUCTION

FROM the inception of the present intensive development of plastics it has been widely recognized that the materials possess several outstanding properties which commend them for serious consideration as materials of aircraft construction. Up to the present, however, the applications in this direction which have received most attention consist chiefly of certain structural parts, a wide range of fittings and several more or less important accessories. It will be sufficient for the purposes of this brief review to indicate some few of the more important of such developments.

For structural parts and for airscrews, probably the most significant development has been the evolution of improved synthetic resins reinforced with textiles, whereby considerable improvements in mechanical properties have been achieved. The development of synthetic adhesive resins with high adhesive qualities and excellent resistance to penetration by moisture has also played a considerable part in the evolution of stronger and much more reliable laminated woods.

Transparent thermo-plastics are used largely for instrument covers, windscreens and cockpit covers, windows in cabins and turrets, etc., the advantages which the materials possess over glass for such purposes being, of course, self-evident. The optical qualities of products, in the form of thin sheets, are very satisfactory, being, in fact, comparable with those of high-quality optical glass. For sighting purposes, however, safety glass of the laminated type, incorporating a layer of cellulose acetate, still seems to be the most favoured material. Developments in the evolution of stronger transparent plastics are now producing promising results and are likely to lead to important results in the future.

Synthetic rubbers, particularly those produced from butadiene and from chlorinated olefines, are also being increasingly used by aircraft constructors. Indeed, it would be difficult to name any other group of materials in which the demand for the acquisition to a high degree of some specific physical property, to meet an urgent industrial need, has met with such a ready response from research workers. Engine mountings constitute probably the best-known aircraft use of synthetic rubbers, other important applications consisting of hose, sealing strips, gaskets, washers, etc., which are liable to come into frequent contact with fuels, lubricants and greases; radiator and ignition-system components, in which resistance to the effects of heat is essential; protective coverings for metal parts subject to corrosive influences; and fabrics possessing a high degree of impermeability to hydrogen.

It is the potentialities of plastics as materials for the construction of major components of the airframe, however, that inevitably arouse the interest of the aircraft engineer. Moulding methods of forming offer by far and away the most direct path to mass production, a feature to which considerable stimulus is given by the urgent needs arising out of the present conflict. Extreme smoothness of surface, to attain which causes much complication and expense in the all-metal aircraft, is a property of plastic materials almost equal in importance to ease of forming, whilst stable constitution and resistance to penetration by moisture are further properties desirable to the aircraft constructor.

A non-stressed fuselage covering of plastic was used some 20 years ago, whilst during the past three years interesting developments have taken place with regard to more ambitious use of plastics in the airframe. Cellulose materials impregnated with phenolic resins have been found to offer the greatest promise, moulded wings having been successfully produced and the experience gained thereby embodied in experimental designs of aircraft. Much of this development work is, naturally, being carried out under conditions of secrecy, but it may be stated that considerable progress is being made towards the elimination of the more serious difficulties which confronted the experimenters.

From the point of view of the materials themselves, attention has necessarily been focused on the achievement of a satisfactory combination of strength, modulus of elasticity and specific gravity. As in all cases of adapting new materials, however, special designs of spars, ribs and stiffeners have been found necessary and have naturally been evolved in the case of plastics with particular regard to the forming methods employed. Advantage is also being taken of the large amount of experimental work which has been carried out on the techniques of improving the stiffness of thin metal sheets.

Much yet remains to be done before the large-scale use of plastics in this field can be clearly envisaged, but current developments undoubtedly point to the possibility that the stronger plastic materials may yet provide

the solution to the peculiar requirements regarding stiffness and strength encountered in the modern airframe.

Obviously, the whole subject is of extreme importance to the plastics industry as well as aircraft production. We therefore propose to lay special emphasis on these developments in our future issues.

Technology of Plastics

IT is rather astonishing to reflect that, although the synthetic plastics have now been established for some 25 years, they are apparently still not considered, by engineers, in their true light, namely, as logical additions to the ever-growing list of media for structural purposes. This being so, it is not surprising to observe that, in the collected reports of the last meeting of the International Association for the Testing of Materials, no adequate reference to them was made.

The position would be understandable, had the plastics industry itself not devoted considerable time in research to the problems involved. Recently, however, it has become very apparent that, in certain fields at least, considerable thought has been lavished upon the problems to be encountered. Such work, so far, has been mainly confined to individual industries, and has not yet assumed a general aspect.

Principally of interest to-day is the aircraft industry and, here, fundamental data of immense importance are being amassed. Unfortunately, by its very nature, it must, for some time, remain largely confidential. Nevertheless, the increasing potentialities revealed are not being lost sight of by the plastics manufacturers, who, however, for the full realization of their aims, must gain the complete co-operation of the structural engineer.

It is at this point that difficulty arises. As with every other material, exploitation of plastics began in isolated fields, the demands of which were adequately met by the immediate properties in the materials offered. In assessing the value of material for structural purposes, however, it should be borne in mind that whilst, initially, valuable use may be found for media, the physical and mechanical characteristics of which are apparently confined to narrow limits, utilization to the full can be achieved only by modifying designs to suit the new materials and at the same time broadening the range of properties in the materials themselves, in order that they may readily find a still larger scope.

This line of development has been common to almost all metals and alloys. In the case of the steels, development came suddenly after a long and relatively static period. Many alloys of aluminium and magnesium, however, were actually evolved to meet specific demands and their genesis in this respect bears a striking resemblance to that of many of the new plastic media.

Even a casual study of the development of metallic alloys over the past 25 years reveals the interesting fact that, quite apart from the production of an increasingly large number of "mixtures," each possessing in a greater or lesser degree some specific and outstanding quality, there has been gained during that time an even more remarkable degree of control over the range of properties exhibited by individual alloys. Purely chemical properties, such as corrosion resistance, physical properties, such as thermal expansivity, and mechanical properties, such as fatigue strength, can virtually be adjusted to any desired figure.

Plastics, it must be confessed, have not yet reached such an advanced stage of evolution; evidence is not wanting, however, to demonstrate that the deficiency is rapidly being supplied. With the creation of a well-defined system of "plastography," if we may coin a word, analogous to the science of metallography, the process of reaching maturity will be rendered less painful and more rapid.

Elsewhere in this issue will be found a brief dissertation upon the means whereby this end may be attained. In particular, we would refer to the so-called conducting rubber; a material evolved, it is granted, for a specific purpose, but one which may well find increasing application in many fields other than that of aircraft.

Reference is also made to certain tentative attempts to modify what is commonly regarded as one of the fundamental properties of all plastics, namely, low heat conductivity. Paradoxical as this may sound, it has long been recognized that could such an adjustment be effected, many difficulties at present associated with the use of these materials in engineering would at once be eliminated.

In connection with bearings, especially, this need is most pressing. Plastic bearings, which possess so many unique properties foreign to metallic alloys employed for the same purposes, will find at once a vastly increased field of application when once problems associated with heat dissipation are overcome. It is interesting to note that, in their efforts to attain the desired results, those engaged upon this work have enlisted the aid of the metals. One of the newest branches of metallurgical science has been called in to play its part, and serious attempts have been made to utilize metal powder fillers. Further co-operation along these lines between the two interests, and with ceramics, is eminently desirable.

Plastic Helmets

FOLLOWING reports in several daily papers regarding the issue of a new type of "tin" hat to bus conductors and similar outdoor workers, several readers have asked whether our campaign for synthetic resin moulded helmets had borne fruit at last. It is with some regret that we must confess this is not so. We have little information beyond the fact that the new helmet is fabricated (presumably moulded) of "rag" or similar textile fibre and the statement that there is no synthetic resin binder in it. One authority states that it has nearly four times the impact strength of a plastic helmet; if this is so, then the plastics industry will welcome the material for more reasons than one. We do hear, however, that the helmets so made are water absorbent and need a coating of water-resistant lacquer.

The Month's Best Idea

We have received a letter from our friend and contributor Mr. D. A. Dearle, who is with a well-known American moulding concern, that past and future sums of money due to him for articles he writes for this journal should be turned over to a war charity in this country. We shall have the greatest pleasure in carrying out his wishes.

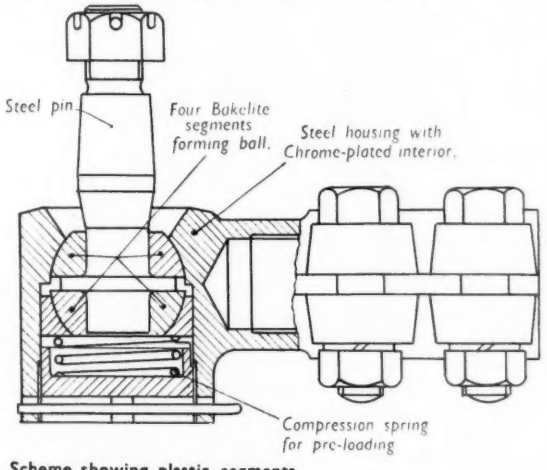
British Plastics Federation

Major Stanley M. Mohr, O.B.E., M.C., has been re-elected chairman of the British Plastics Federation for 1940-41. Major Mohr is managing director of the Micanite and Insulators Co., Ltd., E.17.

Bakelite Bearings for Steering Joints

SOME little time ago it was known that a plastic material was in use by at least one German car manufacturer for steering-pivot bearings. For more than a year past a British concern, Automotive Products Co., Ltd., of London and Leamington Spa, has experimented with a Bakelite bearing at different points in the steering system and many experimental sets are now undergoing extensive tests by several car manufacturers. Results already obtained indicate that this is likely to be one of the post-war developments in automobile design.

The applications in question are to four points in the steering linkage. At each end of the tie-rod which couples the two front wheels together and also at both


Steel pin.
Four Bakelite segments forming ball.
Steel housing with Chrome-plated interior.
Compression spring for pre-loading

Scheme showing plastic segments used as bearings in steering joints.

ends of the drag-link which connects the front wheel to the drop arm of the steering box, there is a joint which must permit motion in three dimensions. Usually it takes the form of a ball joint.

Mr. G. R. Gates, Chief Engineer of the Lockheed Hydraulic Brake Co., Ltd., a subsidiary of the Automotive Products concern, is a firm believer in the virtues of plastic mouldings when suitably applied. Under his directions, experiments were undertaken to use Bakelite in these joints so as to avoid the need for frequent lubrication. A design was evolved in which the plastic material, in four segments, formed the ball, carried on a steel pin and housed in steel forgings arranged for attachment to the rod or link. This forging has a hemispherical surface machined inside it and the ball is enclosed between that and another similar surface in a plug which is pressed against the ball by a strong spring.

All these parts are housed inside the forging which is closed at one end by a cap over which the forging is peened to make a permanent and watertight joint. At the other end, through which emerges the pin that carries the ball, there is a series of parti-spherical pressings, spring-loaded, so as to seal the joint against dirt and water.

Stages in the development of this device are instructive. The first objective was simply to avoid the need for lubrication. Tests showed that, although that was achieved, it was not possible without much elaboration to exclude all moisture. (The joint is located in a very exposed position under the car and right in the splash of the front wheels.)

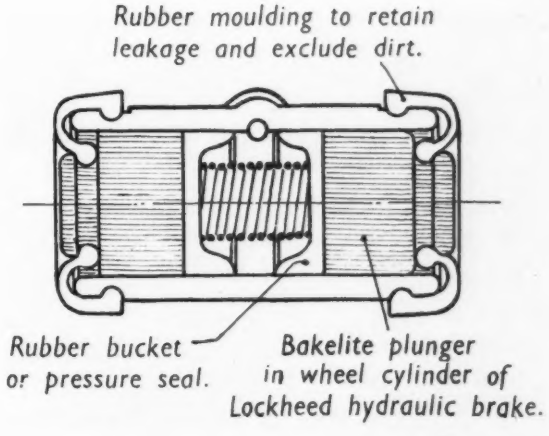
Consequently, the steel surface of the bearings was apt to rust and then the rough surface "filed" the Bakelite quite rapidly. The next step was to chromium-plate the steel surfaces of the bearing. This stopped the rusting and so preserved the Bakelite from attrition.

A chromium surface, however, has its own peculiarities, and amongst them is a tendency to "groan" when used as an unlubricated bearing. To cure this, the Bakelite is impregnated with colloidal graphite. Tests suggest that this completes the necessary development, provided that a suitable initial load is applied to the bearing surface. If allowed to run lightly, it seems that the plastic surface is not too happy, but given a pressure of about 100 lb. per sq. in. or more, it shows no sign of deterioration whatsoever over long periods.

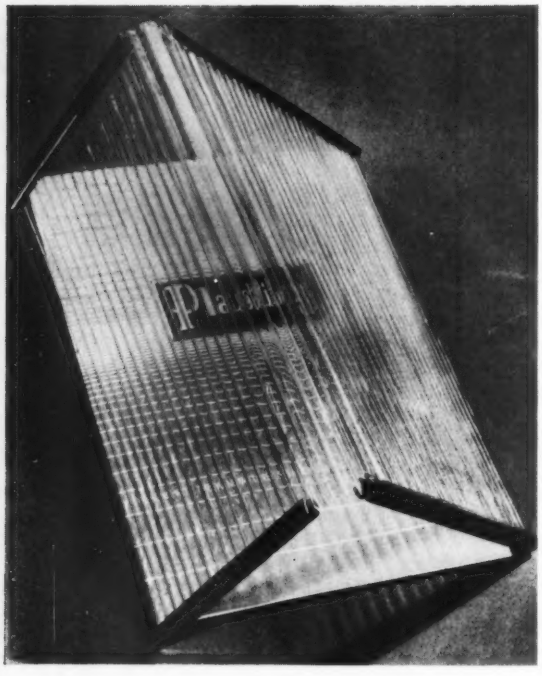
For the user there is the merit that these rather inaccessible parts require no attention. The manufacturer gains indirectly from that and directly from the fact that the Bakelite segments can go straight from the mould to the assembly bench without further machining or finishing.

For these segments the Bakelite employed is a shock-resisting grade that has been used for ball-bearing cages. It has a fabric filler and is loaded, as stated, with a small percentage of graphite. A somewhat simpler Bakelite is being applied by Mr. Gates to a very different job. In the Lockheed hydraulic brake system each wheel carries a small cylinder in which is a pair of plungers bearing one against each shoe. On the other face of each plunger there is a rubber "bucket" which prevents the escape of liquid which, when the brake pedal is depressed, forces the two plungers apart and so expands the brake shoes inside the drum.

These plungers are now being made of Bakelite. In this case lubrication is provided automatically by the operating fluid and no graphite is needed in the mix. The application is one which should give complete satisfaction and the moulding is stressed quite simply in compression.


Rubber moulding to retain leakage and exclude dirt.
Rubber bucket or pressure seal.
Bakelite plunger in wheel cylinder of Lockheed hydraulic brake.

Position of plungers in the hydraulic brake system.



ISOLUMEN

A New Plastic Sheet for the Building Trade

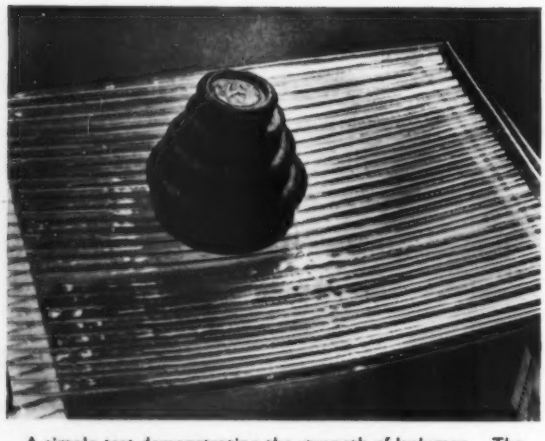
By GEORGE FEJÉR

The accompanying photograph demonstrates the nature of Isolumen, its transparency, its pliability and a method of sheet fixing. It is of a "corrugated" design sandwiched between two acetate sheets, although one sheet applied to the acetate "corrugation" is also used.

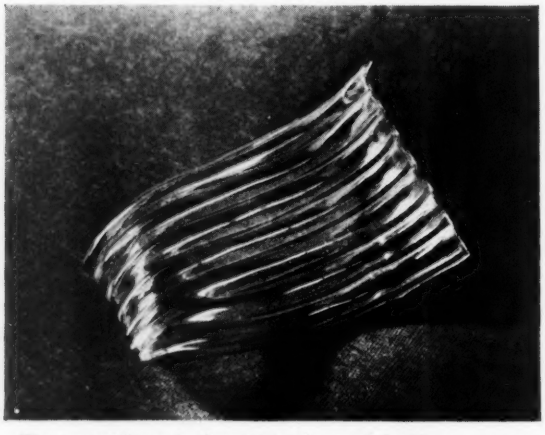
THE tendency to use cellulose derivatives and resinoids in the building trade is increasing rapidly. Responding to the pressing needs experienced under war conditions, it is highly probable that the plastics industry will continue to offer still more innovations to help architects and builders in many ways. Plastic components constitute in some cases not only a "substitute" in the sense of a makeshift but open up fresh fields of enterprise, in which the so-called "substitute" may easily prove itself to be of greater potential value than the material it is intended to replace.

This applies particularly to the material now being produced under the trade name "Isolumen." This product may appear at first sight to be just a useful glass substitute, but in reality it offers new possibilities in construction which could never be achieved with the usual glazing materials. The unusual feature of this translucent slab is that it contains air channels or air chambers, so that although the thickness of the plates ranges between $\frac{1}{8}$th and $\frac{1}{4}$ of an inch, a very low specific weight can be maintained, which is approximately 25 times lighter than glass. The air channels are disposed in a manner as to assure a twofold function: first, the maintenance of the greatest possible statical elasticity of the plate and, secondly, it enables the slab to act as a thermal insulator.

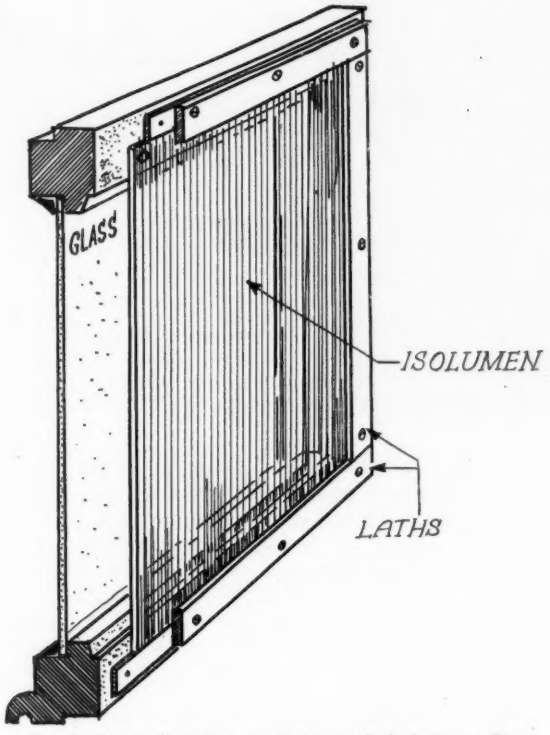
The basic materials for the different varieties of "Isolumen" are composed of known translucent plastics; the variety now being produced for present considerations, viz., A.R.P. purposes, is made of cellulose acetate, in which no fibrous or metallic reinforcement is being used, since the plates have sufficient self-supporting stability against wind or snow pressure, though the resultant material is not as rigid as glass plates. The architect, builder or interior decorator has to deal here with an extremely light, splinter-proof and unbreakable material, which is easy to cut, entirely transparent, and which transmits natural, artificial light, the invisible heat-rays and ultra-violet-rays to a great extent. The



A simple test demonstrating the strength of Isolumen. The weights are 3 lb. 12 oz.



The material can be formed in shapes of double curvature similar to normal acetate sheet.



Simple device for lining a glazing with Isolumen. The elastic sheet prevents the penetration of broken glass into the room.

lightness of weight enables the material to be supplied at a reasonable price, by comparison with other plane-parallel plastic sheets.

War-time Uses, A.R.P.

The experimental studies for "Isolumen" have been made in the years before the war, for peace-time purposes, but it is being produced to-day to replace shattered glazings. Though many emergency replacements are now being made by all sorts of translucent and non-translucent substitutes, "Isolumen" is considered preferable by some of the authorities because of its permanent nature and high degree of translucence. The devastating effects of aerial warfare on glazings was by no means a surprise. In the past 20 years experiments were carried out in many countries to study the distant effects of explosions. The results of accidental explosions in peace-time and the lessons of the last war were familiar to many of us. The "distant effects" are chiefly caused by the vibration of buildings, air pressure and suction and small flying splinters of debris, inflicting damage to glazings over an area often more than a hundred times greater than that subjected to the near effects of a big explosion.

Besides the almost incalculable effects of hits by small flying particles of debris, there are important, complicated, but calculable, factors to be taken into consideration, such as the resonance of the glass panes, or the system of framing, the shape and the treatment of the edges of the glass. These factors are not generally understood by the men in the street, who must often be bewildered on seeing that at some distance from the explosion windows or glass roofs which have been prepared with splinter-proofing devices are frequently shattered, whilst other glass panes nearer to the explosion, and unprotected, remain uncracked. He may tend, therefore, to conclude from his observations that all precautionary methods are useless. It must be stated, however, that the attempts made by the plastics industry to reduce the dangers of shattered glass by the use of compounds and adhesive strips have not been entirely unsuccessful. Of course these are only intended as temporary measures and once the glass is broken it must immediately be replaced.

In many cases, it would not be expedient to replace it with another pane of glass, which is likely to meet the same fate. Therefore it is of the utmost importance to replace it by unbreakable material, preferably transparent.

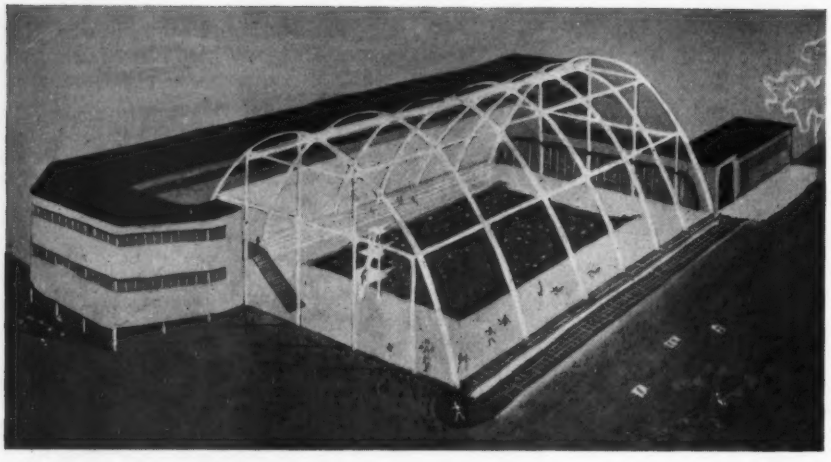
"Isolumen" seems to respond in a highly satisfactory manner to these requirements. If exposed to the quick succession of air pressure and suction, the material makes membrane-like movements, but does not shatter or splinter. Should an "Isolumen" pane be blown out, it could not inflict injuries or damage, and in all probability the same pane could be used again.

Good safety precaution against flying glass may be obtained by fixing "Isolumen" to the inside of existing glazings, or by making laylights with it, because this prevents not only the damage caused by glass dust and splinters of the shattered glass, but keeps out rain, cold and wind when the glass is cracked or broken by the distant effects of an explosion. This precaution results in a minimum loss of daylight if compared with the other available precautionary methods, and it entirely eliminates the damage which might be caused by exposure to weather in the interval which must elapse between the breaking of the glass and its replacement in the usual way.

This precaution is by no means a purely war-time measure, for the "Isolumen" linings will prevent many well-known "disabilities" of glazing such as heat-losses, draught and water condensation which are chiefly caused by the heat-conductivity of glass. When peace comes many people will hasten to demolish their shelters, clean their windows at last from all kinds of more or less adhesive materials, and try to remove everything which reminds them of war. It is not intended that "Isolumen" laylights and linings should be removed. Factories, hospitals and other buildings where daylight without the loss of heating is an ever-present problem can leave "Isolumen" panes on the inside of the glazings, and "Isolumen" will continue to render valuable service by saving fuel in winter.

Properties

Generally speaking, the properties of "Isolumen" now being produced can be compared with those of glass advantageously. The weight of the plate does not exceed 1.8 oz./sq. ft. The light transmission is higher than that of raw-cast or wire-inlaid glass or some ornamental (ribbed) glasses, and is only 12 per cent. less than the average quality of clear window glass. The invisible (infra-red) heat-rays are transmitted by "Isolumen" to a high degree, resulting in a considerable saving of heating material in rooms which must be kept warm. On the other hand, "Isolumen" is not suitable to insulate artificially cooled rooms against sun-rays. Ultra-violet-rays are transmitted by uncoloured "Isolumen" up to 90 per cent. intensity. The spectroscopic analysis has shown very intensive transmission under 2,800 A° (Angström) units. The physiologically important radiation (around the wavelengths 3,021 A°) is very intense through "Isolumen," but is practically entirely absorbed by the usual sorts of glass. The heat-transmission coefficient has been found to be about 13 times lower



An architect's peep into the future use of Isolumen for open air baths.

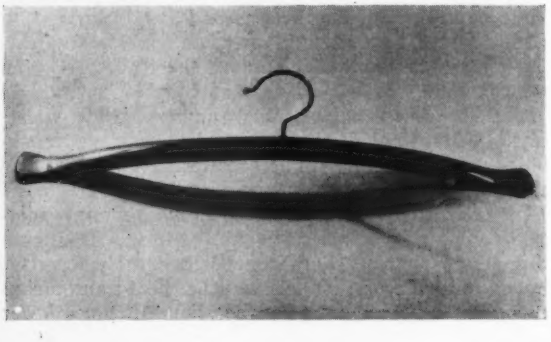
than that of glass ($\lambda = 0.0681$ kg.cal.m.h.°C.), owing to the shape and number of non-convective air channels. Since the material now being produced is made of cellulose acetate, the compound sheet possesses the known thermal properties of the basic material; it is thermoplastic and "non-inflammable." Statically, "Isolumen" has a certain rigidity which varies with the size and ratio of the sides of the rectangular pane according to the theories of the flat plates. (An examination of the mathematical calculation concerning the internal stresses of the plates would lead us far from the subject of this article.) It is clear, however, that the unusual thickness of the plate maintains an exceedingly elastic and comparatively stiff shape, considering that the maximum stresses are in inverse proportion to the square of the thickness of the compound plate, whatever the shape or size.

A special feature from the builder's point of view is the easy method of fitting and fixing. Glass requires careful transport, handling and entirely rigid frame, because any movement of the frame may crack the glass. The framing of "Isolumen" and plastics in general is less delicate. This opens up great possibilities for protecting growing foodstuffs, since problems of light, transportable forcing frames, cloches and even greenhouses are easily solved by using "Isolumen" panes, with the minimum amount of framing. Temporary and semi-temporary barracks, hospital extensions, etc., are often made of timber and insulating wallboards: which are elastic materials, easy to cut, to nail and transport, and in this connection plastics such as "Isolumen" can be used to a greater extent than glass, providing the possibility of translucent constructions where it was not practicable hitherto. It is easy to foresee that after the war architects and decorators will become more and more "plastic-minded." Modern architecture tends to provide buildings with more and more translucent constructions; this tendency will be more justified when the inherent drawbacks of glass will be overcome by the adaptation of plastic materials. In this development "Isolumen" will undoubtedly take its place.

On account of the properties which have been enumerated above, the highly adaptable nature of "Isolumen" suggests that in the near future it will be put to many uses which have not been touched upon in this article.

Plastic Dress Hanger

Rudson, Wood and Co., Ltd., of Ibex House, Minories, London, has sent us a sample of a cellulose acetate coat-hanger moulded by the injection moulding process. It is available in a wide range of colours, scarlet red, pink, royal blue, cream, pastel green and pastel blue, and has been designed to retain the shape of dresses. The hangers are already on sale in London and the Provinces and a large number of export orders have already been booked. Rudson, Wood and Co., Ltd., are the sole distributors. Thomas de la Rue and Co., Ltd., have moulded the hanger.



Synthetic Resin Cements

We congratulate the *Beetle Magazine* for appearing according to plan under conditions that are not exactly normal. In it there appears an article on the above subject which is especially worthy of notice.

Results of tests on the Beetle cement A have recently been made available, and show the great strength of joints made with even thick films of this cement. One interesting test was made on two pieces of walnut joined with a glue layer of 0.03 in. to 0.04 in. thick, the thickness being obtained by the aid of metal distance pieces. The edges of the block containing the distance pieces were then sawn off and the two blocks forcibly separated by driving a steel wedge into the glue layer. The fibres of the walnut were torn away, showing that even a thick layer of cement is stronger than the wood. This is typical of such joints. An important point is that the Beetle cement A shows no evidence of crazing, whereas thick layers of ordinary urea-formaldehyde glues craze badly.

One of the applications of this synthetic cement is in the construction of aircraft, and thus it may be subjected to the very low temperatures experienced at high altitudes. The cement stands up admirably to these conditions.

Plastic Aeroplanes in Production

By HARRY WILKIN PERRY

The following notes will prove of considerable interest in that they give a more complete picture of this new American development than the earlier details we have published on the Timm and Clark aircraft.

MOULDED plastic aeroplanes are now in production for the first time in the United States by a new process called Aeromold. Special plastics and manufacturing processes were developed for the purpose and successful flight tests of the initial model were made last May.

Advantages claimed for aircraft produced of the plastics by the process are that the materials of construction are available in quantities in the United States, 'planes can be produced faster and more economically than by customary methods, they are lighter and faster than others of equal size and power made from usual materials, and are more durable because they are highly resistant to shock, impact and fire, proof against crystallization, corrosion, fungus and attack by wood-boring insects, and impervious to water, oil and petrol.

The new aeroplanes are being built by the Timm Aircraft Corporation in a small new plant at the Los Angeles Municipal Airport in Van Nuys, California, with equipment and plastics developed for the purpose by the staff of the company after careful research backed by experience in the aircraft industry. The only materials of construction used are the special phenolic-resin solutions and fuselage-length strips of spruce plywood 1/24 in. thick. Very little shop equipment is needed for fabricating the aeroplanes, principal items being simple tools for building rough wooden forms, accurate pressure moulds and large steel jigs, and a room-sized oven specially designed and built for baking fuselages, wings and tail components.

All structural parts, such as fuselage stringers and rings, wing spars and ribs, framework of ailerons, stabilizer and rudder, and covering skin for all these elements, are made by laminating the spruce plies and impregnating and bonding them with the plastic. The number of plies in each part is determined by the strength required. Only three are used in the skin, although it takes much of the stress in the monocoque fuselage and monoplane wing.

The process consists of the following principal operations:—

Design of the aeroplane to be built having been decided upon, rough wooden forms are constructed to the approximate size and shape of each individual part of the craft, and corresponding moulds of exact size and shape are made for moulding the parts under pressure. The forms and moulds for making skin are constructed so that the whole covering of the fuselage is made in two half-shells and that of wing panels, ailerons and tail components also is made in matching halves like a clam shell.

A layer of plywood strips as long as the full length of a form are placed on the form successively, with thick coats of liquid resin applied between them and with the grain of the wood crossed. The last layer is bound down temporarily with tapes and the surface sprayed with resin by means of a spray gun.

This rough shape is transferred from the form to a precision mould, where introduction of pressure forces the plastic resin throughout the grain and cells of the wood and moulds the material into precise shape and size. Here the plastic begins to solidify, giving the half-skin definite rigidity, whereupon it is removed and fitted in place on the fuselage rings or wing ribs in an assembly jig with each joint surface saturated with plastic.

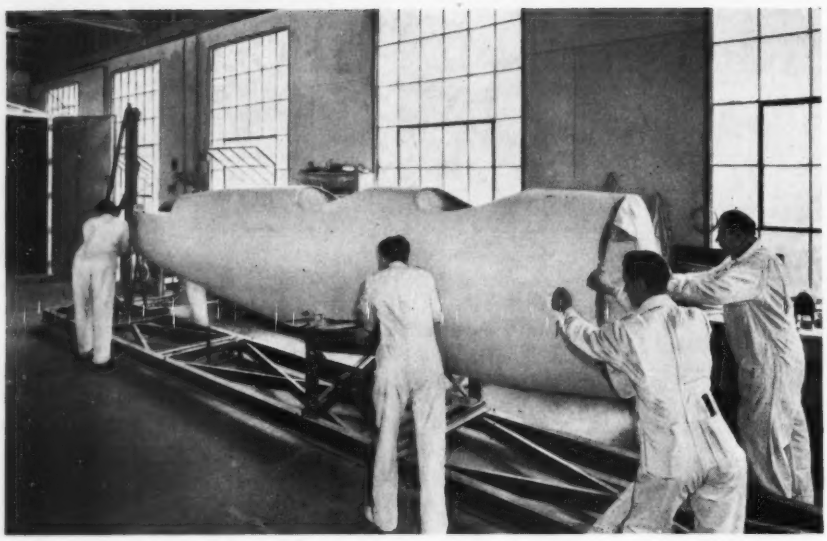
When the fuselage, wing panels and other major parts have each been fully assembled their entire surfaces are again coated with plastic and they are wheeled on the jigs into the oven and cured for several hours at a temperature of 180 to 250 degrees F., with the heat and humidity carefully controlled.

Finally, the wing panels, ailerons and tail parts are mounted on the fuselage, making a complete shell, which is given several coats of special plastic paint and rubbed down to glass-like smoothness that results in optimum reduction of air drag due to turbulence and skin friction. Thereafter the engine, final flying controls, instruments and remaining equipment are installed to complete the aeroplane for flight testing.

As no metal stiffeners, attachments, bolts or rivets are used in fastening the structure together, their cost and the time that would be consumed in making and installing them are saved, the smoothness of streamlined surface contour is unbroken and approximately 20 per cent. is saved in weight of the craft.

Specifications of the first model put into production reflect the aerodynamic efficiency and weight reduction. Designed by Walter A. Hite, chief engineer of the company, to conform to specifications of the U.S. Army Air Corps, it is a military primary trainer of two-place

Moulded section of skin cut to shape for affixing to fuselage frame, and, at left, form for shaping laminated skin to cover one half of fuselage.



Moving the fuselage into the curing chamber.

tandem, open-cockpit type. The dimensions are: wing span, 36 ft.; length, 24 ft. 10 ins.; height, 7 ft. 9 ins. Powered with a five-cylinder radial engine of 160 h.p., it weighs, empty, 1,435 lb., and with a useful load of 615 lb. has a gross weight of 2,050 lb. Performance data are: take-off distance over a 50-ft. obstacle, 1,000 ft.; rate of climb at sea level, 1,025 ft. per min.; maximum speed, 140 m.p.h.; cruising speed, 129 m.p.h.; service ceiling, 19,700 ft.; and landing speed, with flaps, 42 m.p.h.

Superiority in strength and other properties of the structural material produced by the new process has been adequately proved by exhaustive comparative tests with customary aircraft materials. In impact tests, for instance, an 8 lb. iron ball dropped from a height of 7 ft., rebounded 2 ft. after striking a sheet of laminated plastic and did no damage to the material, whereas under the same test a sheet of duralumin of the same size and weight was deformed 8 ins. and very much crumpled.

In fire-resistance tests comparable pieces of plastic and duralumin were subjected to a flame of 1,400 degrees F. temperature from oxy-acetylene torches. The aluminium sheet burned through almost instantly and showed a definite tendency to melt and partly support combustion in the torch flame. By contrast, the plywood plastic was at no time burned through, the only effect being slight charring of the outside layer.

Comparative shear and compression tests were made of joints bonded with the plastic resin and with other known glues. Thus, a wing-rib cap strip having 1 sq. in. of effective area bonded with casein glue, when placed in tension with the rib proper, sheared from the rib at 290 lb. An equivalent cap bonded with Timm special resin, set cold but not heat-treated, parted from the rib at a tension of 316 lb. And a duplicate cap, similarly bonded with the resin and then heat-treated, broke away at 490 lb.

Baking greatly increases strength of joints, as is evident from the above, but is not necessary in the making of field repairs, as in the cold-set state the joints have high shear strength. Therefore, damaged skin can be repaired simply, quickly and cheaply at airports or flying fields.

The Timm construction method is expected to bring much nearer the era of the light, moderate-cost private aeroplane, but is not restricted to production of small craft. R. A. Powell, vice-president and general manager of the Corporation, has made the following statement:—

"The process of manufacture is extremely significant as a mass-production medium for military aircraft. Based on our research and the practical experience of our technical staff, it is indicated that the process offers great possibilities for use in the construction of pursuit and bombardment types of aircraft. It produces a perfect aerodynamic surface, increasing the performance of aircraft of a given size and power. A saving of as much as 20 per cent. in weight is possible, permitting greater performance, larger fuel capacity, more armament, heavier armour plate and greater bomb loads without affecting performance, as circumstances may demand. At the same time, definite reductions in cost are effected, with a much higher potential production rate per sq. ft. of plant area."

In connection with this last point, it is of interest that Mr. Powell has said that, with proper equipment available, three 'planes could be built per day in the company's new, but small, plant, which now has only one 10-ft. by 10-ft. by 40-ft. baking oven.

Under high temperature aluminium sheet is rapidly burned through, while the plastic sheet is only charred.

Changing the Properties of Plastics

IT seems a strange commentary on human inquisitiveness that no sooner is a new material, with special and valuable characteristics of its own, produced than there is apparently an immediate movement to alter its properties to make them approach that of other and distinctly different substances. But the desire so to do is fundamentally sound, in so far as it presupposes the possibility of increasing the measure of control capable of being exercised over such properties, and hence of enhancing the value of the material as a structural medium.

We raise this subject because of the general interest raised in our suggestion (obviously not new) that synthetic resins of the phenol-formaldehyde type may yet be employed for making moulds, and that the necessary heat transmission of these non-heat conducting resins could be raised by previous admixture with finely divided metal. Little work has been carried out on the problem, and although one can be certain that the heat transmission would be thereby improved, it is almost equally certain that other inherent and valuable properties of the plastic will be affected adversely. (See Mr. Fordyce Jones's letter on our "Inquiries and Answers" page.)

One reader points out that mixture with metal is by no means a new thing, and gives as an example the production of cores for radio and telephony. Such cores, however, are not in the same category. Loading coil cores for increasing inductance to a transmission circuit and filter cores for filtering out certain bands of frequency utilize the synthetic resin (which is present only to the extent of about 1 per cent. of the iron powder) merely as a binder and insulator of each metal particle. The whole structure cannot be considered as a plastic shape with metal filler, but rather is a metal structure with a plastic filler.

An example more closely related to the present argument is that of plastic bearings, the apparent thermal conductivity of which is increased by incorporating in the plastic mass strips of aluminium foil, which act as channels for the dissipation of heat.

It should be observed that the successful fulfilment of aims such as those referred to depends on a broad understanding of the problems to be solved. For instance, Melhuish, in a paper on bearings read before the Institution of Automobile Engineers, is guilty of ambiguity when he states that metal-filled plastic bearings did not prove successful because the resin did not bond itself to the metal. No difficulty is to be anticipated in bonding a resin to the dendritic particles of electrolytic copper powder, provided the type of resin and powder selected are suitable for the purpose.

The development of plastics, in common with that of many other constructional materials, has, up to the present, conformed too much to orthodox practice. The properties of materials in their most commonly encountered forms tend to be stressed to a point where they begin to be looked upon as the limits of the possibilties of the materials.

This is deplorable in the case of a vast range of materials of which the physical possibilities are as yet virtually unexplored, and which permit of the use of forming methods of extreme convenience and rapidity.

In many directions cases occur where, if the basic properties of plastics (together with convenient forming methods) could be allied to the possession of some specific physical property, then new wide fields of application would be opened to them.

For example, the commoner types of plastic material are characterized by low electrical and thermal conductivity. In cases where materials are used for insulation purposes such properties are of great importance; but many examples can be cited where the possession of some appreciable degree of electrical and/or thermal conductivity would create entirely new uses for plastics.

A striking example of this lies in the development of electrically conductive rubber, chiefly for the safe discharge of static electricity. The developments have so far been largely confined to rubber derived from natural sources, but they point to directions in which researches upon synthetic products would undoubtedly yield results of importance.

One particularly interesting application of the material is in the aircraft conducting tyre. It is essential that an aircraft be "earthed" immediately it touches down, so that any static electricity accumulated, either by air friction or during a thunder storm, may be discharged without sparking and consequent risk of fire. Cases have occurred, particularly in hot, dry desert climates, of aircraft landing and taxi-ing up to a refuelling point without any suspicion of danger, but immediately contact has been made with the refuelling equipment the spark discharge of static electricity has initiated a disastrous fire. The trouble can be avoided by using trailing chains or wires, but such devices tend to be easily damaged or lost, and, in any case, the day is long past when "odd bits and pieces" could be suspended indiscriminately from an aircraft without seriously impairing its performance.

The filler normally used in tyre treads is gas-black, prepared by the incomplete combustion of natural gases. Due to its fine degree of subdivision (as compared with lamp-black derived from animal sources) it possesses excellent reinforcing properties, and is now incorporated in amounts approximating to 50 per cent. of the rubber weight. In a conducting tyre the filler must function as the dispersion medium, and in this respect the non-conducting gas layer on natural gas-black is a considerable disadvantage. Blacks free from this non-conducting film have, however, now been discovered, which confer the requisite conductivity on the tyre without any sacrifice of the normal properties of the material.

Claims are made in U.S.A. that tyre treads of the conducting type are now being produced with a minimum resistance of 30 ohms/cm^3. This, of course, is a remarkably low figure when compared with the specific resistances of pure rubber and standard tyre tread rubber, 1×10^{16} and 1×10^{9} ohms respectively. In this connection, however, it might be mentioned that tests carried out in this country previous to 1938 revealed the resistance of an aeroplane tail wheel,

measured between the hub and a wet metal plate under the tyre, to be $5 - 10 \times 10^3$ ohms when fitted with a conducting tyre, as compared with 2×10^{10} ohms when a standard tyre was used. It is of importance to note that in these tests a good contact between tyre and hub was ensured by spraying the inside of the rim with aluminium. The time required safely to discharge a large aeroplane with a conducting tyre proved to be as low as .0001 sec., whereas with a standard tyre a time of 20 to 30 minutes is generally found necessary.

Further important examples of the use of electrically conductive rubber are in high-voltage cables, in order to prevent the formation of ozone, and for machinery and conveyor belting, particularly that used in atmospheres containing inflammable dust and gases, where the generation of static electricity would create a serious danger of explosion and fire. Conductive floor coverings in large buildings are also being increasingly adopted in order to ensure uniform floor potential, whilst in the rare cases where such potential is appreciably above that of the earth an additional safety measure can be taken by suitably grounding the floor coverings. Hospital operating theatres, in the atmospheres of which inflammable anæsthetic vapours may exist in appreciable quantities, furnish an excellent example in which the use of conductive floor coverings is to be strongly advocated.

The evolution of such rubbers, it must be noted, is not complicated by the need for maintaining high mechanical properties to anything like the same degree as that encountered in the case of conducting tyre treads. Consequently, greater attention can be given to the attainment of the lowest possible resistance in the finished product. In this connection, it is interesting to note that claims are made in U.S.A.* that materials with a specific resistance as low as 1 ohm have been produced.

From what has been discussed here, it will be seen that controlled variation of physical or mechanical properties may be achieved in several ways. The incorporation of foil strips into plastic bearings is to be considered principally as a mechanical device for increasing heat dissipation, whilst the introduction of a specially treated gas black into a rubber mix in order to attain reasonably good conductivity must be viewed in the light of the physical properties of the degassed carbon particles.

Control may also be achieved by purely chemical means. For instance, an ingenious method of altering the properties of phenolic resin, and probably derived from rubber technique, is that shown in B.P.423,444 (Dunlop Rubber Co.). It consists in mixing sodium sulphide with formaldehyde, phenol and ammonia, refluxing and separating the resultant yellow mass. This, presumably, gives an oil- and solvent-resistant resin which can be mixed with rubber to impart such properties to it.

It would seem fruitful of result if resin admixture with metallic soaps were carried out to note the change in character of the plastic. It is well known that to prevent the accumulation of static electricity in tanks and vessels carrying petroleum spirit, metallic soaps such as magnesium oleate, etc., are dissolved in the solvent. It is not quite clear how these soaps act, although one authority states that the effect is due to the retention in the soap of minute particles of water. Many metallic soaps are resin-like in some aspects and are very tough in texture.

* References to U.S.A. claims are from *The Rubber Age*, Vol. 47, No. 5, pp. 308 and 316.

ETHYLCELLULOSE AND LIGNIN PLASTICS

Dr. G. M. Kline, in the August, 1940, issue of *Modern Plastics*, describes, amongst other raw materials, three that are neither made nor widely used in this country. They are, nevertheless, assuming wide importance in the U.S.A.

Ethylcellulose

The first cellulose ether to be made commercially in America was ethylcellulose. This material was first proposed as an industrially useful product in 1912 by Leuchs in Germany, Lilienfeld in Austria, and H. Dreyfus in France. Lilienfeld was granted a patent in the United States in 1916 for making ethylcellulose and another in 1917 for its use in a plastic composition. The Hercules Powder Co. began making it in this country in 1935 and the Dow Chemical Co. also undertook its manufacture in 1937, marketing their product under the trade name Ethocel. Another cellulose ether, methylcellulose, was announced by the Dow Chemical Co. as available to the trade late in 1939, to be known as Methocel.

Ethylcellulose plastic has not as yet come into general use for aircraft or automotive parts. Its chief applications to date have been in protective coatings, adhesives, paper and fabric coatings, and wire insulation. However, its ready compatibility with resins and plasticizers permits the formulation of compositions which have reasonable hardness, resistance to shock and cold flow, and low moisture-absorbing capacity, and which should find many uses based on these favourable properties. Methylcellulose is water soluble, odourless, tasteless and non-toxic, and yields films which are greaseproof and highly flexible. Its properties indicate possible uses as a dispersing, thickening and emulsifying agent, a sizing material, and for coatings.

Lignin Plastics

The utilization of waste wood and sawdust for the production of moulding compositions has been the objective of a considerable number of investigators for the past 10 years. Wood contains approximately 25 per cent. of lignin, a complex highly reactive organic compound which forms resinous substances when heated with phenols, aldehydes and amines. Some of the early patents for such resinous products are those of Novotny and Romieux, Phillips and Wiehe, Novotny and Kendall, S. W. Prentiss, and Sherrard and Beglinger. In 1937 a lignin plastic first became available under the trade name Benaloid. This was manufactured by the Masonite Corp., Laurel, Miss., in sheet form for laminating, on the basis of a patent issued in 1937 to W. H. Mason, R. M. Boehm and W. E. Koonce. The development of lignin moulding compositions of both the thermo-plastic type for injection and impact moulding and the thermo-setting type involving curing reactions in the mould was announced in 1939 by the Marathon Chemical Co., a division of the Marathon Paper Mills Co. of Rothschild, Wis. In impact moulding the composition is preheated, placed in a mould and given a quick blow such as is delivered by a punch press.

Sheets of lignin plastic can be surfaced with synthetic resins in various colours or can be left with a lustrous black finish for industrial applications not requiring colour. It is made in thicknesses from 0.1 in. to 1.0 in. and is normally furnished only in flat panels. Its dielectric properties are favourable for ordinary insulation purposes. It may be drilled, tapped or turned readily. The possible commercial applications of this type of plastic have just begun to be explored.

PLASTIC MATERIALS

By M. LOUIS FROSSARD

In the September issue we published a translation of the first part of M. Louis Frossard's paper dealing with definitions, classification and the history of plastic materials. In the following, the author deals with their constitution and formation. M. Frossard, who, as we indicated in our last issue, was President of the Organizing Committee of the Journées des Matières Plastiques in Paris in 1939, is one of the leading experts of the French plastics industry.

Constitution

FROM the chemical point of view, all plastic materials, whether natural or artificial, are organic substances of high molecular weight; each molecule is an aggregate of a number of similar elementary groups and may be represented generally as $(R)_n$ where R is the elementary group and n the number of such groups in each molecule—a number that can reach 100, 1,000, 2,000 and sometimes even higher.

Thus $(R)_n$ becomes, for cellulose $(C_6H_{10}O_5)_n$
for rubber $(C_5H_8)_n$
for polystyrene $(C_6H_5\,CH=CH_2)_n$

When submitted to partial destruction by heating, by oxidation or by hydrolysis, these substances of high molecular weight divide into less complex degradation products the analysis of which fixes the chemical composition of R.

The usual methods of determining the molecular weight of these large molecules (and therefore of fixing the value of n) by cryoscopy and determination of osmotic pressure have not proved satisfactory and only the new processes such as those employing ultra-centrifugal methods and the measurement of relative viscosity give good results.

It is important to note that plastics are only very rarely composed of molecules all of which are the same molecular weight, but are almost always mixtures of molecules of different sizes. In such mixtures the value for n is only an average figure. Moreover, the physical properties of these materials varies in a continuous fashion with increase in value of n; for example, for the same plastic, the fusibility and the solubility especially diminish with the increase in molecular weight.

X-ray examination allows us to penetrate still more into the constitution of large molecules and reveals some picture of their internal architecture—it shows that the elementary groupings are disposed within the molecule in two very different ways, conditioning the physical properties of the materials:—

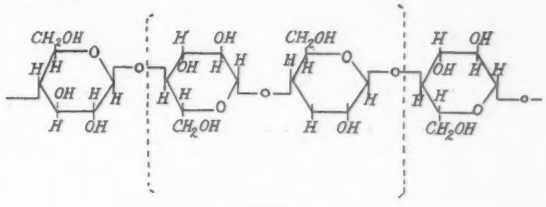
1. In the linear polymers they are aligned one after another in long chains constituting thread-like molecules.

2. In the three-dimensional polymers they are disposed in all directions in space and as a network. This distinction based on the chemical constitution agrees with the practical classification based on the action of heat; linear polymers correspond with thermo-plastics, while the three dimensional polymers are thermo-hardening materials.

(1) Linear polymers.

A. In this category are ranged a large number of natural products of high molecular weights.

(a) The polysaccharides: cellulose, starch, dextrin. We owe to the work of Haworth, Meyer, Staudinger, Trillat, etc., the following configuration for the cellulose molecule:—

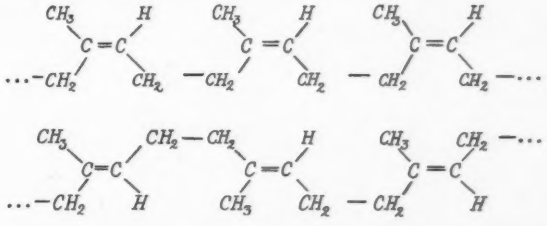


Cellobiose

The molecule is represented as formed from a large number of glucose groups united two by two after a rotation of 180 degrees. This constitutes the cellobiose grouping or motif at least so far as the cellulose of the textile fibres, cotton and ramie, is concerned.

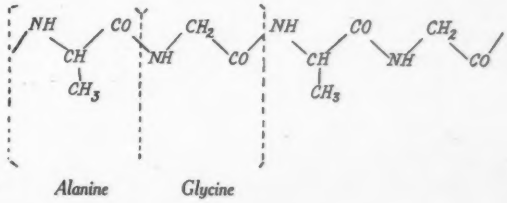
The presence in each glycose nucleus of three OH groups capable of being esterified by acids or their Staudinger and his pupils have shown that the existence trinitrates, triacetates, etc., of cellulose, products which have plastic properties.

(b) Polyprenes: rubber, balata, gutta-percha, in which the molecule is formed from the isoprene unit. Staudinger and his pupils have shown that the existence of double linkages in the chain makes two isomers possible; the cis isomer which constitutes balata and gutta-percha, and the trans isomer which is rubber.



Since the polyprene chain when unstretched gives no X-ray spectra it is generally concluded that the chain is in the form of a spiral, a theory which serves as an explanation of its elasticity.

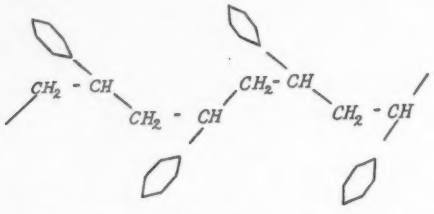
(c) Certain polypeptides: such as the fibroin present in natural silk and which has as its basic groupings the amino acids alamine and glycine. The recognition of this constitution was the starting point of the work of Carothers on the super-polyamides (e.g., nylon).



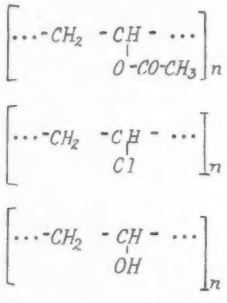
Alanine *Glycine*

B. A large number of artificial products are also classified in the linear polymer group :—

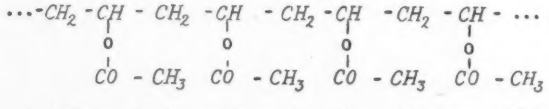
(a) Among the most important are the ethylenic polymers such as polyisobutylenes and polystyrenes. Boer's researches on these have led to the representation of the latter in the form of a paraffin chain with benzene nuclei situated perpendicular to the direction of the chain and following the structure of a spiral.



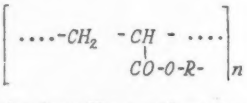
(b) The vinyl polymers: acetates, chlorides, alcohols, etc., of the general formula :—



and the developed formula as follows :—

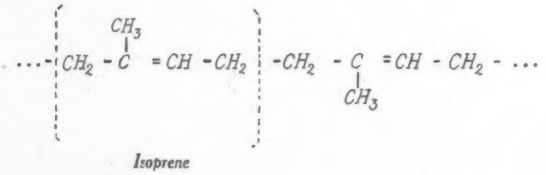


(c) The acrylic and methacrylic polymers which closely resembled the preceding ones, with which they often give co-polymers.



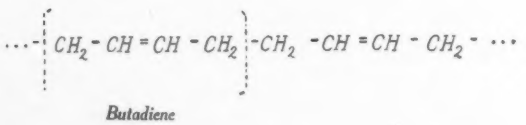
(d) Finally, the butadiene polymers, which produce materials identical with or similar to natural rubber from the point of view of structure.

Natural rubber (polyisoprene): —



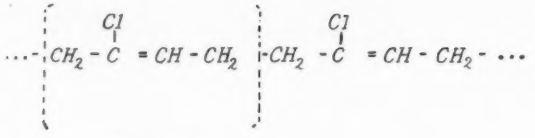
Isoprene

Polybutadiene: —



Butadiene

Polychloroprene: —

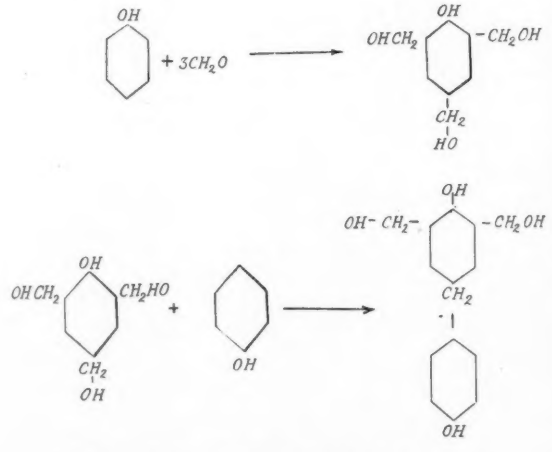


Chloroprene

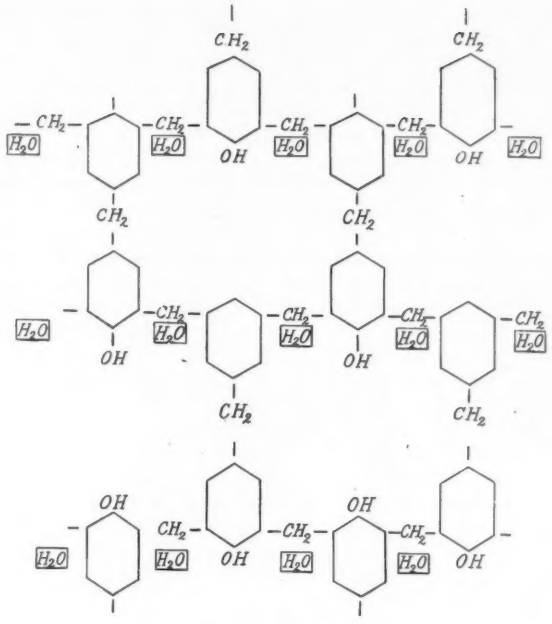
(2) Tridimensional Polymers. Like the preceding linear polymers, these may be grouped into natural and artificial substances.

A. Among the natural substances which are most likely constituted on a basis of heavy molecules may be mentioned proteins such as albumen, gelatine, etc., formed by the condensation of amino acids in long chains analogous to the polypeptide chains already mentioned, but here united among themselves by different bridges which create the three dimensional structures. Other natural substances, of the thread-like form, assume a three-dimensional structure under chemical modification: for example, rubber by vulcanization, drying oils by boiling or air-blowing, casein by formaldehyde treatment, etc.

B. Among the purely synthetic materials of this class are the resins obtained by condensation—phenol-formaldehyde and urea-formaldehyde. The exact formula of the large three-dimensional molecules has not yet been established with certitude, since they become insoluble after a certain degree of condensation and do not give X-ray diffraction spectra. Since the molecular size cannot be determined by any known method, they have been described as possessing "immense" molecular weights. Furthermore, the graphic representation of such products is obviously difficult and whilst they are formed by groups of atoms bound together in three dimensions, it has been the habit to portray them as a sort of development in a plane. Wattermann, following the results of his researches on the destructive hydrogenation of these products, suggests the following for the heat-hardening phenolics :—



(The scheme for heat-hardening phenolics is continued on the next page.)



Formation

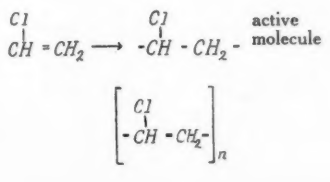
We possess only uncertain data on the manner of formation of the highly polymerized natural substances and these have not yet been verified. The production by living organisms of hydrocarbon or albuminoid materials is obviously very complex, and although many interesting syntheses have been carried out, biochemistry only partially teaches us about the reactions. For cellulose, it is now agreed that the intermediate is formaldehyde produced by the union of carbon dioxide and water, thanks to the action of the chlorophyll in the plant. From formaldehyde is produced sugar and thence polysaccharides: cellulose, starch gums, etc.

In contradistinction, the mechanism of the building-up of artificial substances is much better known; two principal methods of forming large molecules are distinguished, namely, polymerization and polycondensation.

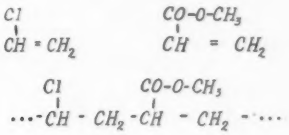
1. Polymerization.

This is the union of many molecules of the same substance called a monomer into one single molecule of a new substance. While this new substance is, on chemical analysis, identical with the original monomer (for example, the proportionate weights of carbon to hydrogen are exactly the same), the molecular weight of the polymer is a multiple of the monomer. Polymerization is always produced by the opening of the multiple linkage—ethylene, acetylene, carbonyl, azomethene, etc.—which exists in the monomer.

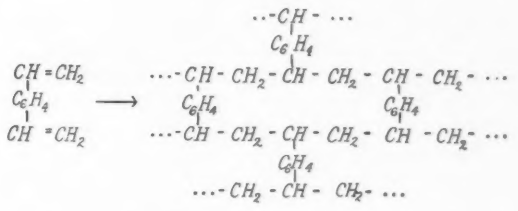
There is first, under the action of a catalyst, a preliminary activation of the elementary molecule. This, then, fixes another molecule and rapidly forms a long chain.



Mixtures of two or more unsaturated substances can be polymerized together and their molecules alternate more or less regularly in the co-polymer chain. Thus, vinyl chloride and methyl methacrylate produce associated molecules such as follows:—

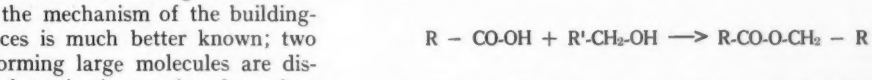


The reactions of polymerization generally lead to the formation of large molecules of linear type, but they can also give rise to three-dimensional polymers as is exemplified in the case of divinyl benzene.

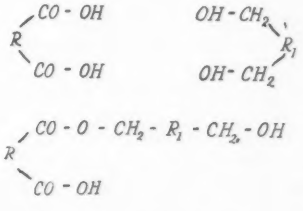


2. Polycondensation.

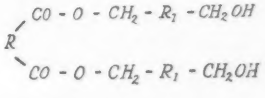
This is the union of a large number of molecules of the same substance or of different substances, reacting between themselves with the elimination during the reaction of water, hydrochloric acid, sodium chloride, etc. Polycondensation can only lead to the formation of large molecules if the product of the initial reaction retains reaction functions which can give rise to new condensations. Thus a mono-acid reacting with a mono-alcohol forms an ester which cannot give rise to a new condensation and the "functionality" of the acid is nil.



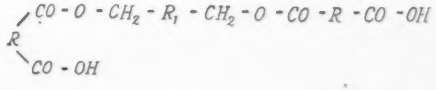
A dibasic acid, however, reacting on a dialcohol can give rise to bodies still possessing a certain functionality.



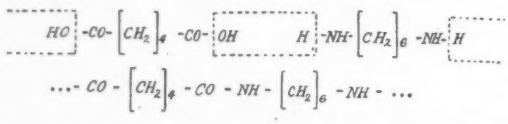
or with two molecules of dialcohol.



or again if the diacid is in excess.



It can readily be realized that with tribasic acids and trialcohols the reactions may be still more complex. Polycondensation gives rise either to the tridimensional polymers of the Bakelite type or to linear polymers of the superpolyamide type, the latter formation being as follows:—



Sometimes both formations from the same substances are possible. Thus phenol and formaldehyde condense in an acid medium giving novalacs of linear structure, while in alkaline medium they give rise to the three-dimensional structure already described.

Conclusion

Within the terms of this cursory review, it may be asked how far scientific theories have been able to guide the evolution of the plastics industry, the essential stages of which have been given. It is certain that at the beginning most of the industrial results were obtained by empirical research—the scientific interpretation of the results and the exact determination of the chemical reactions which are at the base of the manufacture came much later.

During the past few years, however, we are present at a reversal of this tendency. Thus the arrival at a point where synthetic rubber can be produced was rendered possible thanks only to the knowledge of the chemical constitution of the polyprenes; the work of Carothers and his collaborators ended satisfactorily only because of the scientific work carried out on the constitution of natural silk.

In order to reach success in similar work, laboratories must have at their command important resources, financial, material and personnel.

If we confine ourselves to the last-named, that is to the brains behind the research, the following figures are interesting.

Between 1930 and 1934 no less than 36 different pupils or assistants were associated with the name of Professor Staudinger, professor at the University of Fribourg; between 1931 and 1937, 22 chemists are mentioned in the patents taken out by E. I. Du Pont de Nemours on chloroprene rubber, whilst 27 chemists of the I.G. worked on polybutadienes during the same period.

If to these and similar figures, used only in pure chemical research, is added the number of personnel required to put the process into an industrial scale, the number necessary to devise applications and to construct special machines without which plastic materials could not be used, we can measure the extent of this scientific and technical development, and we can realize immediately the conditions under which this effort must be followed in France.

It is indispensable to support chairs in the Universities and Schools specializing in the domain of chemistry, and to maintain around the professors a nursery of chemists indispensable not only for the carrying out of pure research work, but also for the evolution of processes within the works of the chemical industries. The development of the plastics industry is an excellent example.

Modern Alarm Systems

EFFORTS TO MEET THE WAR-TIME FIRE MENACE

IT seems logical to believe that there will be more widespread use of incendiary bombs as the pace of air hostilities increases. A load of heavy bombs naturally decreases the range and manœuvrability of aircraft, and this suggests that such activities as mass bomb attacks may tend to be confined to military objectives. Apart from this strategy, it seems feasible that the enemy will eventually attempt general dislocation of communication, trying to create as much confusion as possible. For this reason they will probably start fires by dropping incendiary bombs, a large load of which can easily be handled by a bomber.

In combating the effects of fires, especially those created by the incendiary bomb, it seems to be agreed that the major necessities are quick location of source, rapid survey of the situation and prompt action according to plan.

To accomplish this, an efficient alarm system is absolutely indispensable and is, indeed, made compulsory by the Factory Act of 1937, Section 36 (7), which stipulates that "Where in any factory more than 20 persons are employed in the same building or explosive or highly inflammable materials are stored or used in any building in which persons are employed, effective provision shall be made for giving warning in case of fire which shall be clearly audible throughout the building." Managers and officials of all large buildings, whether they be factories or hospitals, office blocks or hotels, will therefore be much concerned with the problem of completing arrangements of this kind against the time of their urgent need.

Suitable Systems

In considering the equipment for this purpose a decision has first to be made as to what form it shall take. Generally speaking, the most popular system of to-day is one involving both audible and visual signalling with telephone communication between the alarm points and the fire chief. A system of this kind complies fully with the suggestions made in the publication issued jointly by the Admiralty, War Office and Air Ministry entitled "Air Raid Precautions for Government Contractors." It is of interest to note that this booklet also advocates that existing house telephone systems should be utilized where possible. Reference to the General Electric Co., Ltd., on this subject brought out the fact that this arrangement, by which the house system is made to perform a dual purpose, is particularly worth bearing in mind when considering cost. It also entails saving in materials, especially wire, which are most difficult to obtain without special orders at the present time.

Details of the system are given in a recent pamphlet issued by the G.E.C.

Control of Plastics

The Minister of Supply has issued the Control of Plastics (No. 1) Order, which came into force on October 1. Plastics in the form of moulding powder in the production of which any of certain raw materials have been used may not be bought, sold or used, except under licence. The raw materials specified are formaldehyde, phenol, cresol, urea, thio-urea and cellulose acetate.

Any inquiries should be addressed to the Ministry of Supply, Plastics Control, Great Burgh, Epsom, Surrey.

We have been informed by the Ministry of Supply (Plastics Control) that Mr. P. A. Delafield has been released from military duties to take up the appointment of Assistant Controller of Plastics. Mr. F. E. Middleditch and Mr. W. E. Pattman have also joined the Control as technical officers.

PRODUCTION

Practical Information dealing with Raw Materials, Moulding and Forming of all types of Plastics—Thermo-Hardening and Thermo-Plastic—Works-Organization, New Plant and Control Apparatus

NOTES AND COMMENTS

Glass Substitutes

ONE immediate result of the blitzkrieg has been the demand for window-glass substitutes and the publication of Bulletin No. C.10 on "Flexible Substitutes for Glass," by the Ministry of Home Security. The Bulletin is a most useful one, describing the desirable properties of such materials and the method of using them; furthermore, there is a useful list of manufactured materials available. It appears unwise to replace broken glass with new glass, in view of the risk of repeated attack and because new glass would, in turn, require protective treatment. Further, supplies of materials for protective treatment can be expected to serve only a fraction of the glass at present in use. The utility of a flexible substitute for glass that can be harmlessly dislodged by blast and readily replaced is therefore obvious.

Flexible substitutes may be either translucent, or, where permanent obscuration is required, opaque. Most translucent substitutes are at present made of synthetic resins or cellulose substances reinforced with metal or textile mesh.

Alternatively, cotton or linen textiles may be used; these are not ordinarily windproof or rainproof, but may be obtained suitably treated with cellulose lacquer.

QUALITIES.—The desirable qualities in translucent glass substitutes are:—

(1) *Reasonable translucency*.—Materials having a transparency and light-transmission approaching that of glass are expensive and difficult to obtain owing to their use in aircraft. The majority of the cheaper translucent materials transmit less light than glass and interfere in some degree with clear vision.

(2) *Weatherproofness*.—The material should not be porous (as is untreated cotton sheeting) or it will become soaked with rain and is also likely to admit wind enough to make interiors uncomfortable in cold weather. Attention should be paid where necessary to the sealing of the edges of the material.

There are many substitute materials on the market, and the provisional list below gives some of their names. The list, however, does not aim at being comprehensive, and simply includes the names of those which are known to the Department to be on the market.

"Armourbex."—Cellulose-acetate sheet reinforced with wire mesh. Thickness 22/1000 in. Sheets 55 ins. by 24 ins. Price approximately 10s. per sq. yd. British Xylonite Co., Ltd., Hale End, London, E.4.

"Celiglas."—Moisture-proofed viscose film reinforced with textile fabric. Price 1s. 6d. per sq. yd. British Celilynd, Ltd., Burwell Works, Lea Bridge, Leyton, London, E.10.

"Cellofabric."—Cellulose-acetate film reinforced with textile fabric. Prices, 18 ins. wide, thickness 5/1000, 13s. per sq. yd.; 3/1000, 7s.; 2/1000, 4s. 6d. Cellofabrics, Ltd., 11, Gillingham Street, London, S.W.1.

"Del Beta."—Cellulose-acetate film reinforced with textile fabric. Prices, 18 ins. wide, G.R.3, 4s. per sq. yd.; G.R.4, 5s.; G.R.5, 10s. Dobsons and M. Browne, Ltd., Del Beta House, Nottingham.

"Dufaynet."—Cellulose-acetate film reinforced with textile fabric. Price, 22 ins. wide, 2s. 9d. per sq. yd. Dufay-Chromex, Ltd., P. and O. House, 14-16, Cockspur Street, London, S.W.1.

"Ferrophane."—An expanded metal mesh coated with a film of ethyl-cellulose. Sheets 54 ins. by 24 ins. Price 8s. 3d. per sq. yd. Ferrophane, Ltd., 52, West Ham Lane, London, E.15.

"Marvol."—36 ins. and 48 ins. wide. Saville, Marvel and Co., Ltd., Port Street Works, Manchester, 1.

"Nuart."—Cellulose film reinforced by filet net. Two qualities of net, 40 ins. wide. A. and F. H. Parkes (Nottingham), Ltd., Anglo-Scotian Mills, Beeston, Notts.

"Rexine."—A cotton fabric, impregnated with cellulose acetate. Price, 40 ins. wide, 2s. 9d. per sq. yd. I.C.I. Rexine, Ltd., Imperial Chemical House, Millbank, London.

"Steadoglass."—A cotton fabric, impregnated with linseed oil. Price, 36 ins. and 50 ins. wide, 3s. 3d. per sq. yd. Also "Super Quality," 27 ins. wide. Storeys, Ltd., Lancaster.

"Sunralite."—A fine wire mesh coated with a film of cellulose acetate. Price, 36 ins. wide, 4s. 6d. per sq. yd. Sunralite, Ltd., 84, Chestnut Road, London, N.17.

"Textuff."—A cotton fabric, impregnated with viscose. Three thicknesses. Price, 37 ins. wide, 11d. to 1s. 2d. per sq. yd. Textuff, Ltd., care of Capt. Kilner, Tree Tops, Dollis Avenue, London, N.3.

"Windolite."—A fine wire mesh coated with a film of cellulose acetate. Price, 36 ins. wide, 4s. 6d. per sq. yd. Windolite, Ltd., Harlow, Essex.

Unnamed substitutes:—

Impregnated fabric.—Three qualities, all 36 ins. wide. Prices 1s. 1d., 1s. 5d., 1s. 8d. per sq. yd. M. Barr and Co., Ltd., 28, Miller Street, Glasgow, C.1.

Plastic reinforced with glass silk.—James Clark and Eaton, Scoresby House, Glasshill Street, London, S.E.1.

Impregnated fabric.—Price, 37 ins. wide, 1s. 1d. per sq. yd. Horrockses Crewdson and Co., Ltd., Yard Works, Preston.

Fabrics impregnated with special lacquer.—Jenson and Nicholson, Ltd., Jenson House, Stratford, London, E.15.

"Ordinary" Chromium Plating

By E. E. HALLS

It is rare to encounter chromium plating in the moulding works. The process is not always present in the tool-making factory, since the work is specialized. Yet the occasion often arises for serious consideration of its inclusion as a unit. The following notes, which bear special reference to the plating of taps and reamers, describe a simple procedure which is worth close examination.

IT is many years ago that the electroplater came to the assistance of the toolmaker with an established technique for depositing a film of chromium on tools, where required, and having properties of great hardness, low coefficient of friction and good wear. Tools for relatively normal classes of work were thus enabled to yield longer runs between regrinds and overall longer service. Tooling propositions of milling, hobbing, drilling, etc., that were exceedingly difficult or of low efficiency, were improved and rendered commercially successful. Gauges that rapidly became out of commission or scrapped due to wear, plated with this chromium, became especially popular for several reasons. They remained within limits of accuracy for longer spells of working, they could be rebuilt to original dimensions by replating and, in consequence, inspection efficiency could be increased with lower costs. The class of chromium plating required for purposes of this nature is rather specialized and over a period of years all the factors involved have been gradually perfected. The plating conditions are not arduous, solution and control being straightforward and cold solutions usually being employed. Methods of stopping-off surfaces not required to receive plating have been devised, special holders for the work designed, and special anodes developed to suit the low-efficiency electrolyte involved and to lead the deposit most effectively to the areas to be plated. In many cases, however, a technique has had to be acquired to "let down" slightly the hardness of the tool before plating by careful tempering, to decide the best thickness of coating and to ensure the soundest method of final grinding of the somewhat brittle deposit to finished size. For example, this applies to gauges, and quite a good procedure is to temper down to a hardness of about 500 DPN, to have surfaces about 0.002 in. undersize (0.004 in. on a diameter or width dimension), to apply a chromium thickness of 0.004 to 0.005 in. and so allow for inequalities of plating thickness and to permit final grinding to accurate dimensions. The tool designer also has had to give assistance by designing his work to facilitate the plating and final grinding operations; for example, by allowing slight radii instead of calling for sharp edges on the tool before plating. In consequence of the all-round intricate nature of chromium plating for tool work, it will be found that relatively few commercial electroplaters have specialized in the art, and that, likewise, relatively few industrial engineering concerns have set up sections to cater for it. In general, it will be found that Continental technicians utilize this meritorious process more than do those in this country.

The purpose of this article is to inform readers of an exceedingly simple process of chromium plating that has proved invaluable when applied to taps, reamers and drills, and that has been introduced especially for dealing with the more "refractory" plastics. The method in its entirety is strongly contrasted with that briefly summarized in the foregoing. It employs the ordinary bright chromium-plating solution, normal equipment, standard conditions of temperature and current density, as well as of precleaning and subsequent washing. Moreover, no special consideration has to be given to the tools with respect to shape and dimensions, the plating is, in effect, merely a "flash" coating and no after-grindings are entailed. In the following are presented brief details of the process and notes on the field in which it has proved particularly advantageous.

The recommended plating process for taps and reamers for use with plastics is, in effect, the simplest one normally employed for bright chromium on polished articles for decorative and protective purposes. The electrolyte is made up as under:—

Chromic acid	50 oz.
Sulphuric acid	0.5 oz.
Water	1 gallon

The chrome acid should be the specially pure grade marketed for electroplating. Ordinary commercial grades are unsatisfactory. It should be completely soluble in water, 99.5 per cent. minimum parity, 0.10 per cent. maximum sulphuric-acid content, the remaining allowable impurities being water and alkali salts (as chromates). The sulphuric acid may be the normal commercial concentrated sulphuric acid of specific gravity approximately 1.85.

The compositional balance of the electrolyte is of prime importance and the 100/1 ratio of chromic to sulphuric acid must be maintained. These constituents may safely fall to 40 and 0.4 oz. per gallon, but the sulphuric acid specially must not be allowed to rise above the 0.5 oz. figure. Control by periodic chemical analysis is essential. All the chromium deposited is taken from the solution, and this has to be replaced by additions of chromic acid. Drag-out losses have to be made up by additions of both ingredients and evaporation losses by additions of water.

The chromium-plating solution is usually operated in a lead-lined steel tank, loosely lined with glass plates. Small equipments can use glass or chemical stoneware. The working temperature must be controlled to 45-50 degrees C., and for large loads both heating and cooling coils are necessary; the latter are not required for the present purpose. Anodes are antimonical lead. Voltage can be of the order of 2 volts, but current density should be controlled to 100 amps./sq. ft. Surface areas can be calculated with sufficient accuracy on average diameter.

As the cathode efficiency of current density is low (between 10 and 20 per cent.), bus bars must be of adequate section and contacts must be good. Nevertheless, it suffices to wire taps and reamers around the shanks. They can be completely immersed.

Work must be thoroughly clean, but ordinary processes are satisfactory. All dirt, machining compound, grease, etc., must be removed, with particular

reference to flutes. Alkali degreasing may be sufficient, but scouring might also be necessary. Hot 5 to 10 per cent. caustic-soda solution, or 4 oz. of each soda ash and sodium meta silicate per gallon, can be used for the former, and wire brushing with No. 250 pumice or Vienna lime for the latter. After water-washing to remove alkali, then a brief dip (15 to 20 seconds) in a 50/50 mixture of commercial hydrochloric acid and water, and again thoroughly water-washing, the work is passed direct to the chromium-plating solution. A cast-iron or welded-steel tank heated with internal steam coils or by external gas burners is suitable for the alkali clean and for water-washes. Lead-lined or ebonite-lined steel or earthenware is satisfactory for the acid pickle.

Investigations into the best thicknesses of plating were made by trial runs on taps and reamers plated for varying time periods. The most satisfactory proved to be 10-minute plating time at a current density of 100 amps./sq. ft. and a temperature of 45-50 degrees C. or at the outside 40-50 degrees. After plating, thorough water-washing and drying is given.

Under the above conditions the thickness of chromium deposited is of the order of 0.0002 in., and so no upset of dimensions occurs. The plated tools are ready for service.

Where bright chromium-plating plants are already installed, it can be seen that no difficulties arise in doing this class of work in the normal plating plant. It is only a question of specifying the current density to be employed for batches of so many of each size of tool. Where plant does not exist, then the chemical laboratory can perform the work on a small scale set up. The heavy current supply required can be taken from the A.C. mains with appropriate transformer and rectifier. A suggested circuit diagram is shown in Fig. 1. Regarding plant, as the plating is so rapid, a small plating vat, either lead-lined, welded steel or glass, can

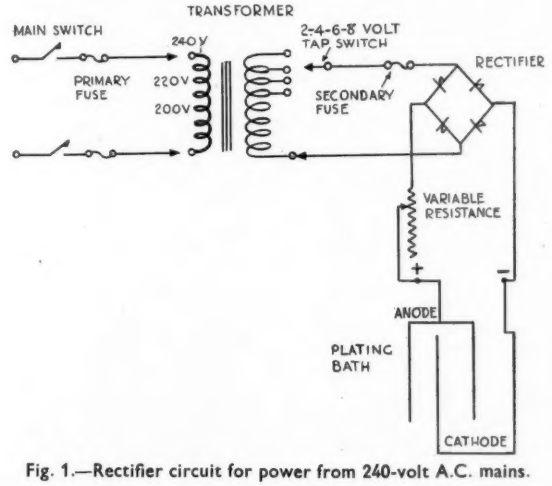


Fig. 1.—Rectifier circuit for power from 240-volt A.C. mains.

be arranged with gas heating. Chromium fume has to be removed owing to health hazards, and therefore the vat can be arranged beneath a hood with exhaust and spray trap. A simple arrangement is shown in Fig. 2.

Plastics present in general no special difficulties in machining, provided the nature of the materials concerned is borne in mind and the right tools and machining speeds are observed. In tapping and similar cutting operations, which, incidentally, are the most

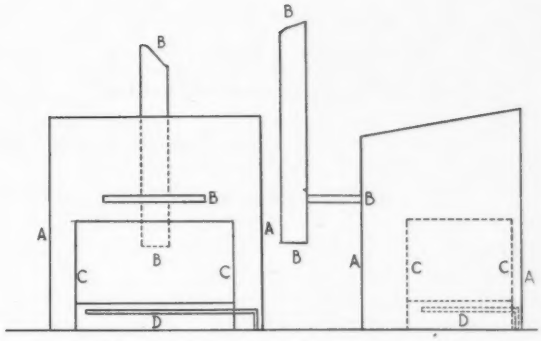


Fig. 2.—Laboratory chromium plating plant. AA, hood; BBB, exhaust; CC, plating tank; D, gas burner.

arduous of cutting processes, the phenolic and amino products are somewhat refractory. Those heavily loaded with mineral matter are most awkward, due to the abrasive nature of the loading and the blunting effect it exerts on tools. Thus, the mica-loaded phenolic mouldings and the pigmented mouldings call for special consideration. Likewise the heavily loaded ebonites, such as those containing about 50 per cent. of siliceous matter (that is, the composite insulating materials used extensively for high-frequency electrical purposes) fall in the difficultly machineable group. Again, moulded phenolic boards and rods, and the glass-bonded mica product known as mycalex, belong to the same category. It is for these materials that the flash chromium treatment for taps and reamers, and in some cases, too, for drills, is strongly advocated, and success assured. Not only is time saved and fewer tools employed, but accurate machining is achieved.

The success of the thin film of chromium lies largely in its low coefficient of friction. Particularly when tapping blind holes, the tap binds and after performing a few operations seizes; it may break off or crack the work. The chromium prevents this, and as the chromium gradually wears off after long runs the operator can tell by the feel of the tool when to change it to prevent seizing. It can then be ground back and replated. On phenolic mouldings, and on loaded ebonite components, where, without plating, tapping of blind holes proved unsatisfactory due to only two to five operations being practicable before breakage, chromium plating enabled 200 to 300 tappings to be performed with entire satisfaction. In all less-drastic cases studied an increased production of at least tenfold resulted.

Solvent Recovery

THE importance of solvent recovery in plastics production and in impregnation processes is growing steadily. We have pleasure in announcing that Price Stutfield and Co., Ltd., of 110, Fenchurch Street, London, E.C.3, for many years representatives of Carbonisation et Charbons Actifs of Paris (owners of the "Acticarbone" Patents and Processes), have been given a licence by the Trading with the Enemy Branch (Treasury and Board of Trade) to continue all the activities of "Acticarbone" in the United Kingdom and British Empire. This licence includes the use of all the "Acticarbone" patents and processes.

Facilities are available for the completion of all plants in construction and the study of all problems of solvent recovery with the provision of plants made entirely in this country.

Inquiries and Answers

(In Which is Included General Correspondence)

Plastic Motor Bodies

Coventry.

Recently the possibility of manufacturing motorcar bodies from plastic materials has come again into prominence. Can you tell me what is the possibility of repairing a plastic body subsequent to a minor accident?

Nobody, I imagine, doubts the possibility of manufacturing plastic bodies in the fairly near future, and there are reasons to believe that the all-important question of cost also may be answered satisfactorily before long. What seems doubtful to me is the ability to carry out repairs without inordinate delay or expense.

In the case of the steel body, much can be done by forcing a crumpled panel back into something like its original shape—by hammering, by rolling or even by pressing. With the aid of solder or some other filler, and paintwork, all traces of damage can thus be removed. In extreme cases, where the metal is badly torn, a panel, or part of one, can be cut away and a new part can be welded into place. The result in either case may be "as good as new."

Can any similar repair be effected with a plastic body? Or is anything of the sort envisaged, even though the practical methods be not quite obvious at present?

It appears to me that no known plastic material which is likely to be valuable for the construction of bodies is likely also to be amenable to any sort of reforming process such as hammering, rolling or pressing. Is that so, or is it conceivable that some substance would meet the requirements?

Assuming my fears are well grounded, the only method of repair would seem to be to cut away the damaged part and to attach a new moulding. To do this, I suppose that it would be necessary to cut away a complete original moulding. (I take it that anything so large as a car body would be built up of a number of smaller mouldings.) Thus it would be necessary for the repairer to cut back to the original "glued" joint, and this seems to me to call for rather more skill and accuracy than can be expected without the aid of jigs. Is it reasonable, therefore, to suppose that the repair of a plastic car body could normally be effected only by the original manufacturer or some organization equally well equipped?

E. P. Willoughby.

[Editor's Note.—The inquirer has raised an obvious problem which has been worrying the plastic industry ever since the subject was mooted. On the whole it would appear that whatever the plastic, thermo-setting or thermo-plastic, almost all damage would necessitate repair by experts.

It appears clear that if motorcar bodies are to be made of plastics, they will be of the wood impregnated and laminated type in units—doors, roofs, luggage compartment doors, etc. Alternatively, they may be made from fibre "floated" emulsion impregnated material in mouldable sheet form. So far only thermo-setting resins have been used for preparing such sheets and, on curing, this produces a strong and suitable finished moulding. The work on this type of structure by the Auto Union is well known. Undoubtedly, however, if a panel were crumpled, the whole panel must be replaced by a new one. Neither hammering, rolling or normal pressing would remove traces of the damage, so far as present experience goes.

A somewhat different case is presented by thermo-plastics. A dent or even a crack can be repaired by heat and pressure in the former instance, or by intelligent use of solvent in the second, but it is doubtful whether these operations could be carried out by the car owner as simply as he can repair a dent in a steel car.

So far, the only thermo-plastic unit of a car we have seen, apart from facia-boards, etc., was a large mudguard of cellulose acetate. This material has never, we believe, been considered for making bodies, except for exhibition purposes; reinforced thermo-plastics, except for certain small uses such as window "glass," hurricane lamp "glasses," etc., have not been produced.

If one may look into the future with the facility of journalists, it is not without the bounds of possibility that a thermo-plastic material may yet be produced by such carefully controlled polymerization that it will be rigid for all practical purposes and yet retain a certain elasticity.]

Plastic Moulds

London, S.W.10.

I have noted with interest your remarks on plastic moulds, on page 205, of September edition of *Plastics*. As an idea your suggestions are good, but your readers should know that this addition of copper powder or copper in any form for rubber moulding is useless.

Of all the metals, copper is perhaps the greatest enemy of rubber, the sulphur of vulcanization produces the black stain of copper sulphide and destruction of the rubber soon results. The same may be said of manganese, which is another enemy.

The best metal to use for your suggestion would be finely divided aluminium; this has been used not only for electric conductivity but for heat conductivity, thus opposing the natural advantages of rubber as an insulator in this connection.

The addition of metallic powder naturally reduces mechanical strength, but it has specific benefits in the vulcanization of rubber. It has been found that heat-cured bathing caps with the addition of finely divided pure aluminium, absolutely free from copper or manganese, has added greatly to the durability of the rubber, as well as improving the cure, evidently caused by a better transfer of heat through the mass at vulcanization temperature.

You are, of course, aware that both selenium and tellurium in powdered form have been used as secondary vulcanizers of rubber and have valuable effects on the vulcanized product.

With reference to suggestions about plastic moulds, they, of course, are only suitable for low-temperature, highly accelerated cures, and where high pressures are used must be strongly reinforced with the addition of metal plugs running through the mould from top to bottom, thus saving the plastic or hard rubber mould from too high a pressure.

My company has used hard rubber and bakelite moulds, but they have been found suitable only for comparatively low-temperature and low-pressure cures.

As a matter of interest, some time ago we made rubber mats impressed directly from lace, the resultant white rubber being cured in the plastic mould, giving a very fine moulding; the difficulty was that the moulds have a comparatively short life.

FORDYCE JONES.
The Reliance Rubber Co., Ltd.

[EDITOR'S NOTE.—The above letter from Mr. Fordyce Jones, who is one of the best-known technologists in the rubber industry, is most interesting and helpful. We are well aware of the danger of copper and manganese to rubber and wonder whether Mr. Jones has gathered that we suggested a rubber mould mixed with copper powder for moulding rubber heels, whereas we suggested a moulded phenol-formaldehyde mould treated in this way. We had imagined that by proper mixing with the phenol-formaldehyde resin that each particle of copper powder would have been insulated from attack by the sulphur in the rubber. This theory is supported by our acquaintance with a plastic made with a brass filing filler and in which the brass has remained bright for some years. However, if Mr. Fordyce Jones is certain of its detrimental effect, even under such conditions, there is little more to say. We must add also that the original idea was that the resin moulding industry could also use such heat-conducting synthetic resin moulds.]

Polystyrene White Opaque

London, W.C.2.

With reference to your comments on Polystyrene in the September issue of your journal, we would advise you that we have a small parcel of about 2½ tons of this material of which we are anxious to dispose.

This is not a product which we normally handle and was sent to us in error from the United States.

We shall be glad to contact any of your readers who are interested in this parcel.

SCOTT BADER AND CO., LTD.

Transparent Rubber-like Plastics

London, S.W.6.

Can you please inform us where we may obtain a transparent rubber or rubber-like material?

This should be capable of being moulded, and have properties corresponding roughly to those of a rubber-bung, as used in laboratory work.

D. H. BANGHAM, Principal Scientific Officer,
The British Coal Utilization Research Association.

[EDITOR'S NOTE.—Several synthetic rubber-like polymers are translucent, but we have not yet seen a perfectly transparent one. The polyvinyl chlorides and polythene might suit the inquirer's purposes. Inquiries should be made to I.C.I. (Plastics), Ltd., British Tyre and Rubber Co., Ltd., and F. A. Hughes and Co., Ltd.]

THE EMPIRE AT WAR

SOUTH AFRICA

Army

A contingent from the Union has arrived in Kenya. This is the advance guard of a much larger South African army to follow.

The South Africans in Kenya include all auxiliaries, such as medical services, engineers, signallers and motor transport. The Union has sent nurses with the force and scores of girl clerks and stenographers. The South African Field Force will be a self-contained, separately organized unit.

Raw Materials

A drive to collect thousands of tons of scrap iron and steel for use in South Africa's iron and steel works is to be launched in the rural areas of the Union.

INDIA

On July 27 the all-India Congress Committee approved the decision of the Working Committee of June 21 to abandon the principle of non-violence in regard to external aggression.

An ordinance issued July 24 introduced into the recently passed National Service (European-British subjects) Act the compulsory principle for the recruitment of European British subjects, other than those domiciled in India, for work of national importance, either in the armed forces or in a civilian capacity.

Prince Aly Khan, son of the Aga Khan, made an appeal to Moslems "to help Britain with all their united energy" in a broadcast on the Jerusalem radio.

Army

Recruits are pouring in, and 15,000 have been enlisted during the first month since recruitment opened.

The Territorial Force has been increased by 25 per cent., several new classes have been given opportunities to enlist, including Bengalis, Biharis, and the Bhandaris of Bombay.

Air

The Government of India is seconding 24 pilot officers from the Indian Air Force Volunteer Reserve to the Royal Air Force. The men selected are training at Lahore before going to Great Britain. There are 13 Indian officers in the R.A.F. at present.

Mobilization of War Industries

The plan for the manufacture of aeroplanes in India has now taken shape. A joint stock company, to be known as the Indian Aircraft Company, Ltd., has been registered in Bombay, with a capital of five crore of rupees (£3,750,000).

All ordnance factories are working 22 hours a day.

Civil factories are making new kinds of armaments, including 40 mm. armour-plating for tanks, and an Indian type of Bren-gun carrier, mounted on wheels, for covering long distances. One factory plans to make Mills bombs.

The Artificers' School at Jubbulpore has been expanded, and the number undergoing training has been raised from 1,000 to 1,800.

A British Mission from India has arrived in the U.S.A. to buy warplanes, machine tools and other materials. Negotiations have been opened to establish a warplane factory in India under American direction.

Gifts

The Maharaja of Sirmur has presented a Valentia aircraft to the Air Forces in India.

The Maharaja of Bhavanager has given Rs. 50,000 (£3,750) to King George's Fund for Sailors to help Indian seamen.

Wadhwan State has given Rs. 1,000 to the same fund.

The province of Sind has already sent one lakh of rupees (£7,500) to the U.K. for a fighter, and hopes to send this week a second lakh for a Sind fighter No. 2.

The East India Fund has cabled a further £20,000 to the U.K. for Spitfires, bringing the total to £75,000.

The Maharaja of Gondal has given the U.K. one lakh of rupees (£7,500) for helping evacuated children.

The Viceroy's War Purposes Fund now exceeds £760,000. The Maharaja of Mysore gave five lakhs of rupees (£37,500) to the Fund.

The East India Fund for buying Spitfires for the R.A.F. received £88,000 from The Royal Calcutta Turf Club.

The Bombay War Gifts Fund totalled 6½ lakhs of rupees (£48,750) on July 26.

NEW MATERIALS—NEW PLANT—NEW METHODS

Centrifugal Pump

The ordinary arrangement of a centrifugal pump combined with a motor consists of separate units mounted on a baseplate common to the two and having their shafts suitably coupled. Such an arrangement necessitates the aligning of four bearings. This is a matter of some difficulty initially in the maker's works, and of still greater difficulty on site, owing to the flexibility of all long and shallow baseplates and to their distortion with the greatest ease, especially under the forces used in making the pipe joints. In order to overcome this difficulty, flexible couplings are introduced between the pump and motor. The majority of these really only permit of relative axial movements of the shafts and do not accommodate malalignment, with the result that driving power is wasted and bearings suffer. These disadvantages are most marked in the smaller units. To obviate these difficulties, the Mopump was originated, in the design of which both baseplate and coupling were eliminated. In this Mopump the motor and pump form one unit, the alignment of the various parts being assured by accurately turned spigots. The makers are Rhodes, Brydon and Youatt, Ltd., Stockport.

Welding Process

The latest scientific welding development is a new Barimar process for welding together ferrous and non-ferrous metals, such as steel and aluminium.

The process, which is complex, must not be confused with any other form of brazing or soldering, as it is a genuine weld, that is to say, there is fusive union of such strength that the breaking point at the junction is not less than that of the weaker metal, as in the case of a weld joining two pieces of the same metal. The success of this development is dependent upon a new form of flux, unusual methods of manipulation and extremely accurate flame control.

A few years ago Barimar, Ltd., the scientific welding repair specialists, of 14-18, Lamb's Conduit Street, London, W.C.1, introduced a process for welding steel to cast iron; so successful have been the results that this firm has carried out intensive research in the welding of ferrous to non-ferrous metals culminating in the success described.

There is no need to emphasize the importance of this Barimar effort; already the new process is being used by this firm for work of a highly important nature. It seems likely that there will be innumerable applications not only in the field of repair work but also for many manufacturing purposes.

Laboratory Porcelain (B.S. 914)

The British Standards Institution has just issued a British Standard, No. 914, for Tests for Laboratory Porcelain. The tests included are:—Appearance, shape, weight, etc., porosity of body and imperfections in glaze (dye test), resistance to heat and sudden change of temperature, constancy of weight and resistance of glaze to high temperature and resistance of glaze to acid and alkali.

The tests thus provided should be helpful both to the manufacturers and the user; to the former in helping him to improve his product, and to the latter in assisting him to avoid the disappointment of porcelain ware being found defective in actual use, although its defects were not previously evident.

Several tests are based on those adopted by the Sub-committee on porcelain of the Glass Research Committee of the Institute of Chemistry and published in 1920. One test, however, that of the resistance to heating and cooling, is entirely new, it being an accelerated test, having no counterpart in laboratory practice. It is considered, however, that it offers the manufacturer a consistent, rapid and convenient control of the quality both of his standard material and of any experimental material he may be investigating. The porcelain industry in this country is developing rapidly and it is hoped that the publication of this British Standard will assist in the further improvement of the quality of British laboratory porcelain ware.

Copies of the above Standard (No. 914) may be obtained from the British Standards Institution, 28, Victoria Street, S.W.1. Price 2s. 3d.

Price List of Chemicals

Messrs. W. and J. George, Ltd., Proprietors of F. E. Becker and Co., have recently issued a new 96-page price list of Laboratory Chemicals, Analytical Reagents, Stains and Solutions. A feature which will commend itself at once is the setting out in the body of the list of the maximum limits of impurity to which the analytical reagents conform; and each bottle of Nivoc Analytical Reagent now bears a guarantee to this effect.

Tablet Machines

The present activities of Manesty Machines, Ltd., of Speke Hall Road, Liverpool, are still, as formerly, devoted to the production of tableting machines and automatic water stills. The demands of the fighting Services are now taking a considerable proportion of the output, but the home and export civil demands have not been overlooked, and wherever possible new or improved models are being introduced. Included in these is the Manesty No. 2 machine. This is a single- or multiple-punch medium-sized tablet machine to a very handsome and modern design, so arranged that practically all the working parts are totally enclosed and every necessary adjustment can be operated with the minimum of time or effort. A self-contained motor drive is built into the machine where required, and the whole forms a very compact unit. This machine is fitted with a safety pressure device.

A further new machine in the Manesty range is the Manesty RS. 1, which is a large Rotary machine of very rugged construction, and capable of large outputs of heavy-weight tablets. The maximum pressure is in the neighbourhood of 8 tons, and the machine is fitted with 21 dies and the appropriate number of punches. All the controls are fitted in the front of the machine, and in addition to a built-in motor drive, a variable-speed drive is incorporated.

Apiezon Waxes and Cements

We have received a catalogue from W. Edwards and Co., the well-known vacuum equipment manufacturers, describing the Apiezon products now sold by them. These are oils, waxes, cements, greases, etc., used on high-vacuum pumps. Since many such materials were imported from Germany and countries now under its influence, the availability of these materials to British users is of considerable importance. The greases and waxes are used for taps and permanent and semi-permanent joints at very low pressures. Black Wax is Messrs. Edwards and Co.'s own substitute for the German "Picein." It adheres well to glass and metal, and is sufficiently yielding at 15 degrees C. to avoid cracking in use. W.E.Wax 3 is a brown wax which has been especially developed for uses requiring high melting point and great tensile strength.